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(71) *Sökande* *Atlas Copco Tools AB Nacka, Stockholm SE*
Applicant (s)

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Görel Gustafsson

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PATENT- OCH REGISTRERINGSVERKET
SWEDEN

Postadress/Adress
Box 5055
S-102 42 STOCKHOLM

Telefon/Phone
+46 8 782 25 00
Vx 08-782 25 00

Telex
17978
PATOREG S

Telefax
+46 8 666 02 86
08-666 02 86

Method for governing the operation of a pneumatic impulse wrench and a power screw joint tightening tool system.

The invention relates to a method and a power tool system for screw joint tightening, where the power tool system comprises a pneumatic impulse wrench, and a programmable control unit is arranged to control the operation of the impulse wrench according to a predetermined tightening strategy and in response to instantaneous values of one or more tightening parameters by regulating during tightening the pressure air supply to the impulse wrench.

A problem concerned with pneumatically powered impulse wrenches is the difficulty to govern the tightening process accurately enough to ensure a correct and reliable pre-tensioning result. In a previously known impulse wrench system, described in U.S. Patent No. 5,366,026, the output shaft of an impulse wrench is provided with a torque transducer for detecting the torque magnitudes of the delivered torque impulses, and a control unit for calculating a torque based clamping force and for initiating power shut-off as a certain co-efficient representing an increasing clamping force has reached a certain value. There is also described a way to more safely arrive at the desired final clamping force by reducing the motive pressure air supply to the impulse wrench as the difference between a desired final clamping force and the actual calculated clamping force is smaller than a predetermined value.

This known tightening system has two weak points from the reliability point of view, namely that the actual instantaneous tightening parameter values, like the torque magnitude, are obtained from an easily disturbed torque transducer including a magnetostrictive output shaft portion and electric coils mounted in the impulse wrench housing. This arrangement is not only sensitive to external

disturbances resulting in a less reliable torque magnitude detection but it is rather space demanding and adds in a negative way to the outer dimensions of the impulse wrench. The magnetostrictive output shaft comprises a number of slots which weaken the shaft and call for an enlarged output shaft diameter.

Although this prior art patent describes a process control where the output torque of the impulse wrench is reduced as the clamping force magnitude approaches the target value, there is still a problem involved when tightening so called hard joints, i.e. joints having a steep torque growth characteristic. This is due to the fact that the very first impulse delivered by the impulse wrench could turn out to be powerful enough to cause a torque overshoot, i.e. reaching a torque magnitude that is higher than the desired final torque level. There is nothing described in this document about how to deal with this problem.

In WO 02/083366 there is described a technique for determining the installed torque based on signals delivered by an angle sensing means mounted on the inertia drive member of the impulse unit. This technique means that the delivered torque is calculated from the angular movements per time unit of the impulse unit, and that no torque sensing means on the output shaft is required. However, there is nothing described about how to control a screw joint tightening process by changing the output of the impulse wrench during the tightening process, for instance how to avoid over-tightening at the very first delivered torque impulse at hard joints.

It is the object of the invention to provide a method for governing a screw joint tightening process performed by a pneumatic impulse wrench which is controlled in such a way that overtightening of the screw joint is safely avoided under all conditions, and a power tool system for

performing the method and including a pneumatic impulse wrench which combines a simple and compact design with a reliable parameter magnitude sensing and ascertaining.

A preferred embodiment of the invention is described below with reference to the accompanying drawing.

In the drawing

Fig. 1 illustrates a power tool system according to the invention.

Fig. 2 shows an enlarged fractional view of the impulse wrench shown in Fig. 1 and illustrates the angular movement sensing device.

The power tool system illustrated in Fig. 1 comprises a pneumatic impulse wrench 10 including a motor 11 with a rotor 12, an impulse unit 13 including an inertia drive member 14 connected to the motor rotor 12, and an output shaft 15. The impulse wrench 10 further comprises an angular movement detecting device 16 which includes a disc 17 with a magnetised rim portion 18. The disc 17 is rigidly affixed to and co-rotating with the inertia drive member 14, and a stationary sensing device 19 located approximately to the magnetised rim portion 18 of the disc 17. The rim portion 18 is magnetised to provide a number of magnetic poles equally distributed along its periphery, and the sensing device 19 comprises sensor elements 120 carried on a connection board 20 and activated by the magnetic poles of the rim portion 18 to deliver electric signals in response to the movement of the disc 17.. The connector board 20 is coupled to a circuit board 21 which carries a number of electronic components (not shown) for treating the signals delivered by the sensor elements 120 and sending secondary signals to a stationary programmable control unit 22 via a multi-core cable 24. Pressure air is supplied to the impulse wrench via a hose 25 and a flow regulating valve 26 which communicates with a pressure air

source and which is connected to the control unit 22 for receiving operating signals. The flow regulating valve 26 is of the type that is able to adjust the air flow magnitude successively in the range between zero and full power flow as determined by the signals delivered by the control unit 22.

The signals delivered by the movement detecting device 16 correspond to the rotational movement of the drive member 14 and are used for calculating not only the speed and retardation of the drive member 14 but also the installed torque, because with the knowledge of the total inertia of the rotating parts, i.e. the drive member 14 and the connected motor rotor 12, the energy and hence the installed torque magnitude of each delivered torque impulse may be calculated. This method of torque calculation is previously described per se in the above mentioned WO 02/083366.

Based on this previously described torque determination method the operation of the impulse wrench is governed by controlling the pressure air supply to the impulse wrench motor via the flow regulating valve 26. According to the invention the pressure air supply is controlled such that a reduced motor power and speed is obtained before and during the very first one or two delivered torque impulse or impulses, whereafter a full power pressure air supply is delivered to the impulse wrench motor. When reaching a certain torque magnitude or a torque magnitude that is a certain percentage of the set target torque level, for instance 80% of the target torque level, the air flow regulating valve 26 is instructed by the control unit 22 to reduce the air supply flow to a certain level or a predetermined percentage of the full power flow, for instance 80% of the full power flow, to thereby reduce the rotation speed of the power tool 10 towards the end of the tightening process and minimise the risk of overtightening

the screw joint due to the influence of inertia related dynamic forces. As the set target torque level is reached the flow regulating valve 26 is instructed to further reduce the air supply flow so as to interrupt the tightening process either by stopping the impulse wrench or by maintaining the installed torque magnitude via a continued impulse delivery at a further reduced torque magnitude in each impulse.

Claims.

1. Method for governing the operation of a pneumatic impulse wrench when tightening screw joints to a target torque level by controlling via a programmable control unit the output of the impulse wrench in response to the instantaneous ascertained values of one or more tightening parameter, wherein the impulse wrench comprises a pressure air driven motor with a rotor, and an impulse unit with an inertia drive member connected to the motor rotor, said method comprising:

- programming the control unit according to a desired tightening strategy,
- starting each tightening process by supplying a reduced power pressure air flow to the motor,
- increasing the pressure air supply flow to a high power flow to the motor after at least one initial impulse,
- sensing the angular movement of the drive member,
- determining the instantaneous angular speed and retardation magnitude of the drive member during each delivered torque impulse via the change of the angular movement,
- calculating the transferred torque at each impulse as the sum of the motor output torque and the dynamic torque generated by the total inertia of the drive member and the motor rotor as a function of said determined retardation magnitude,
- reducing the pressure air supply to the motor in accordance with the programmed tightening strategy and as a predetermined part of a target torque level is reached at each impulse for reducing the incremental torque increase up to the target torque level, and
- initiating shut-off of the pressure air supply to the motor as the target torque level has been reached.

2. Power tool system for screw joint tightening, comprising a pneumatic impulse wrench (10), and a control unit (22) programmable according to a desired tightening strategy including a set value or values of one or more tightening parameters of a target torque level, wherein said impulse wrench (10) includes a pressure air driven motor (11) with a rotor (12), an impulse unit (13) with an inertia drive member (14) connected to the motor rotor (12), and a pressure air supply means (25,26) connected to the motor (11),

c h a r a c t e r i z e d in that

- an angle encoder (16) is connected to the control unit (22) and arranged to detect the angular movement of said inertia drive member (14),
- said control unit (22) comprising a means for ascertaining during tightening and based on the detected angular movement of said inertia drive member (14) the instantaneous value or values of one or more tightening parameters at each torque impulse and for comparing the instantaneous parameter value or values with the set parameter value or values of the target torque level, and
- said pressure air supply means (25,26) is connected to the control unit (22) and comprising a flow regulating device (26) which is arranged to successively adjust during tightening the pressure air flow to the motor (11) in a range between zero and full power flow as determined by the control unit (22).

3. Method for tightening a screw joint to a desired target torque level by means of an impulse wrench having an impulse unit with a motor driven inertia drive member, and a programmable control unit arranged to control the power supply to the impulse wrench according to the following steps:

- starting a screw joint tightening process at a reduced power supply to the impulse wrench,
- ascertaining the angular displacement and retardation magnitude of the inertia drive member during each delivered impulse,
- calculating the instantaneous torque magnitude and torque growth during each delivered impulse,
- increasing after the very first delivered impulse the power supply to the impulse wrench in response to the torque growth calculated during the very first impulse,
- reducing the power supply to the impulse wrench in response to the instantaneous torque magnitude and to the calculated torque growth during each impulse after the instantaneous torque magnitude has reached a predetermined part of the desired target torque level, and
- interrupting the power supply to the impulse wrench as the target torque level has been reached.

4. Method according to claim 3, wherein the power supply is increased after the very first delivered impulse to an optimum magnitude determined by the calculated relative torque growth and the installed torque magnitude during the very first delivered impulse in relation to the target torque level.

5. Power wrench system for tightening a screw joint to a desired target torque level, comprising a torque impulse wrench, a programmable control unit, and a power

supply means connected to the impulse wrench and governed by the control unit, wherein the impulse wrench comprises an impulse unit with a motor driven inertia drive member, and a angle sensing means is connected to said inertia drive member to detect the angular movement of said inertia drive member,

c h a r a c t e r i z e d in that

- said power supply means is controlled to supply the impulse wrench with a reduced power until the very first impulse is delivered to the screw joint being worked,
- said control unit is arranged to receive signals from the angle sensing means and to determine the angular displacement and the retardation magnitude of the inertia drive member during each delivered impulse, and to calculate the delivered torque during each impulse, and
- said control unit is arranged to increase the power supply to the impulse wrench after the very first impulse has been delivered, to reduce the power supply to the impulse wrench as the instantaneous torque magnitude has reached a predetermined part of the target torque level, and to interrupt the power supply to the impulse wrench as the target torque level has been reached.

6. Power wrench system according to claim 5, wherein the impulse wrench is pneumatically powered, and said power supply means comprises a valve connected to the control unit and arranged to vary the pressure air supply to the impulse wrench between zero and a full power flow as determined by the control unit.

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Abstract.

A method and a power tool system for screw joint tightening by means of a pneumatic torque impulse power tool (10) controlled by a stationary programmable control unit (22) and via a torque magnitude calculation based on signals delivered by an angle sensing device (16) mounted on the inertia drive member (14) of the impulse unit (13) of the power tool (10), wherein a pressure air is supplied to the power tool via a flow regulating valve (26) which is successively adjustable between zero and full power flow. The flow regulating valve (26) is controlled by the control unit (22) to deliver a reduced power air flow to the power tool (10) before and during the very first delivered impulse, then delivering a full power flow until a certain torque magnitude or a certain percentage of the target torque level is reached, whereafter the air supply flow is again reduced until the target torque level is reached, and when the target torque level is reached the air flow is shut off.

FIG 1

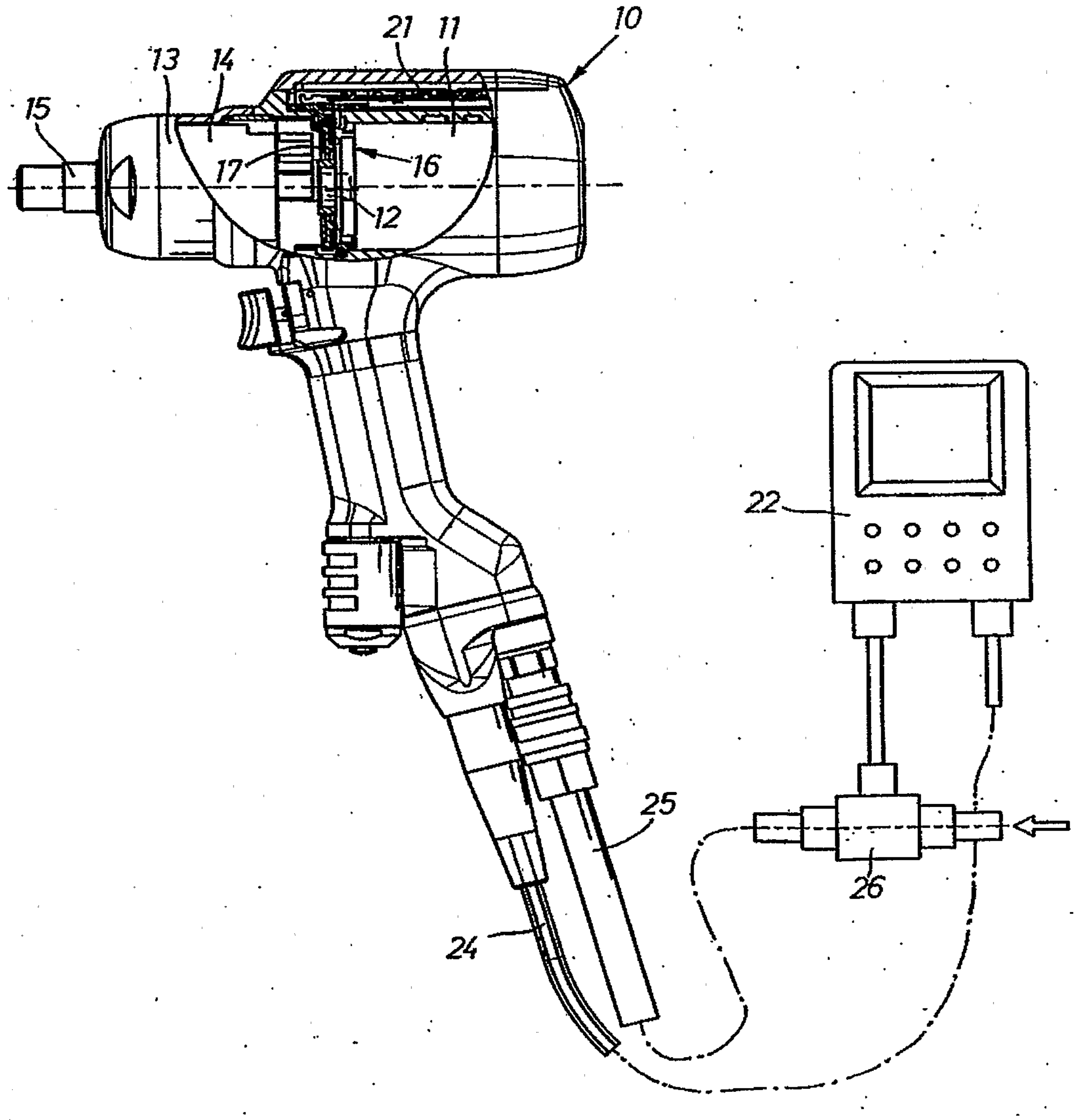

FIG 2